Potential Value-added Products from Wildfire Fuel Mitigation Projects in Eastern Virginia

July 2003

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Acknowledgements

The United States Forest Service, Economic Action Program, Southern Region, and the Virginia Department of Forestry provided financial support for this study. This project was made possible through the assistance of many organizations and cooperators, including the United States Department of Agriculture Forest Service, Virginia Department of Forestry, Natural Resources Conservation Service, the Resource Conservation and Development Councils of Virginia. Three Rivers Soil and Water Conservation District, Middle Peninsula Planning District Commission, Northern Neck Planning District Commission, Virginia Polytechnic Institute and State University, New York State Ranger School, and many others who provided support for this study.

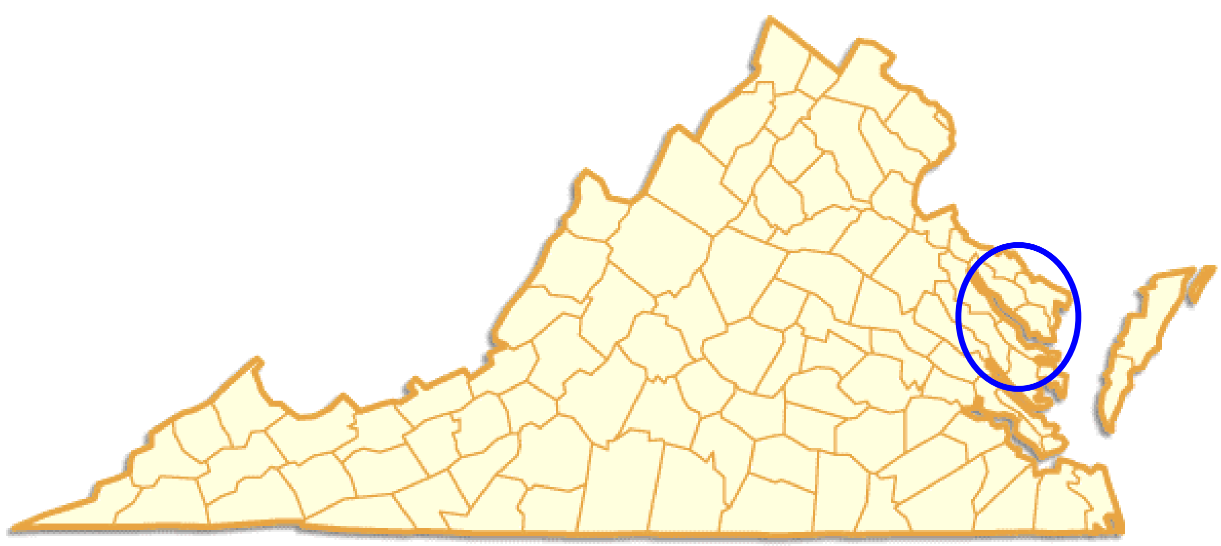
Introduction

This study was initiated to examine the feasibility of increasing the utilization of small diameter (1 – 9 inches) and low value timber in order to create economic opportunities in eastern Virginia, while reducing wildfire risks in the Suburban/Rural Interface. The desired results will be to generate interest from current industries that wish to expand operations, attract new entrepreneurs, and inform interested parties of the potential economic advantages of utilizing these materials.

Population growth, land use conversion, insects, disease, natural disaster, effective wildfire suppression, and underutilization of forest materials have added to the fuel load and wildfire risk within the Tidewater Resource Conservation and Development (RC&D) area of eastern Virginia (Map 1). Finding uses for this low value, underutilized material is an important step in reducing forest fire risk and improving forest management.

Mention of specific products, projects, and manufacturers are for example only and do not signify any endorsement or guarantee of source.

Map 1. Tidewater Resource Conservation and Development Area of Virginia.



Definition of Problem

The Challenge

Current markets for small diameter and low value materials are virtually non-existent in eastern Virginia. The economics of harvesting, transporting, and manufacturing of the materials often relegates them to landfills, open burning, or sometimes piling in inconspicuous places. Often, these materials are not harvested and are left standing on site, a practice that leads to overstocked and unmanaged forests which surround woodland communities. Leaving these undesirable stems in forests and around homes contributes to poor forest health and increased wildfire risks due to lack of management. What contributes to the higher risks are population growth, land use conversion, and the removal of wildfire over the last century. What is needed to promote a healthier forest and limit wildfire risks is education about fire and markets for small diameter and low value timber to ensure that the materials are removed and parcels are managed.

Forest Health

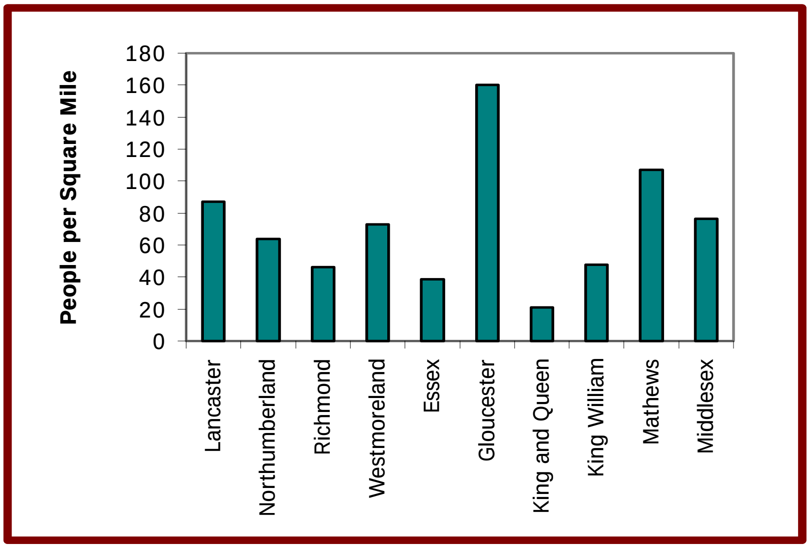
Forest health is a concern for all Virginians. Maintaining forest health keeps trees vigorous, air and water clean, and provides citizens with the materials and recreation they need to enjoy a prosperous lifestyle. As forests progress through ecological succession, they are faced with many uncertainties. Among these are fire, insects, disease, drought, and most recently, development pressures. These pressures endanger the health of our forests by facilitating the removal of forest management. This removal is attributed to development by creating smaller lot sizes, an unfavorable public perception of management activities around homes, local ordinances, and a lack of education. In turn, forests that lack management can suffer from poor health. This reduced health decreases the forest's ability to provide for watershed protection, limits soil and environmental benefits, and makes it harder to fend off natural threats and eventually increases the risk of fire.

Population

"From 1982 to 1997, a development increase of 45% in the South has resulted in a loss of approximately 12 million acres of forestland" (Wear & Greis, 2002). The United States Forest Service ranks population growth and urban sprawl as the greatest threats facing southern forests today (The Forestry Source, January 2002). It is estimated that as a population reaches around 45 people per square mile (psm), the probability of that area supporting traditional commercial forestry practices is limited to approximately 50%. As a population approaches 150 psm, the probabilities of traditional forestry practices existing is near zero (Wear, et al., 1998).

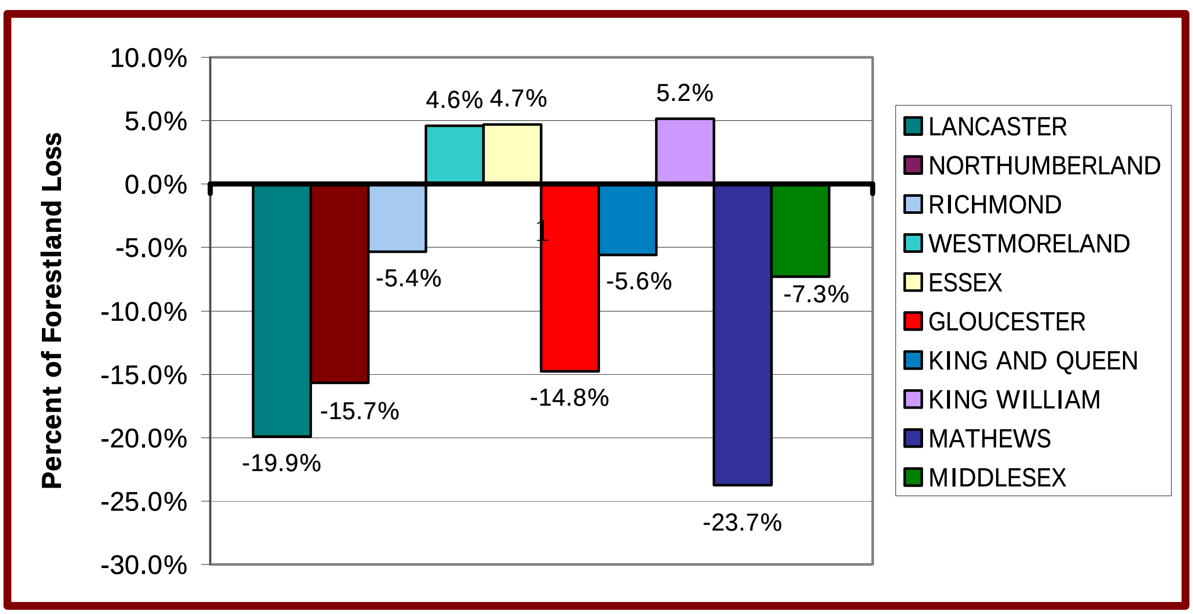
The Tidewater RC&D consists of ten counties within the coastal plain geographic province (Essex, Gloucester, King and Queen, King William, Lancaster, Mathews, Middlesex, Northumberland, Richmond, and Westmoreland counties). The total area is comprised of approximately 2,028 square miles (Virginia Agricultural Statistics Bulletin and Resource Directory, 2000) with an average population growth of 13.3% from 1990 – 2000 (U.S. Census, 2000). This population growth has given the area an average of 72 psm (U.S. Census, 2000). This number would suggest that there should not be a forest industry presence in the area based upon the figures above. However, the growing population has not yet had a negative impact on a forest industry presence in *most* of the area. This is due to the fact that 50% of the counties have much less than 72 psm (King and Queen, 21 psm; King William, 48 psm; Richmond, 46 psm; Northumberland, 64 psm; Essex, 39 psm) (Figure 1). It has however, had a negative impact on a forest industry presence in the higher populated areas where housing development is occurring.

Figure 1. Number of people per square mile by county in the Tidewater RC&D Area (U.S. Census Data, 2002).



In the ten county area, forestland losses are growing. Between the years of 1992 and 1999, an overall loss of 37,501 forestland acres has been converted to non-forest uses (Virginia Department of Forestry, 2002) (Figure 2). This loss represents 10.8% of the total forestland acres in the RC&D area. These losses become increasingly important when dealing with forest health and wildfire concerns resulting from parcelization. As parcelization increases, and the high costs of harvesting low value and small volumes of materials continues, the challenges associated with managing in and around communities will lead to the elimination of essential forest management.

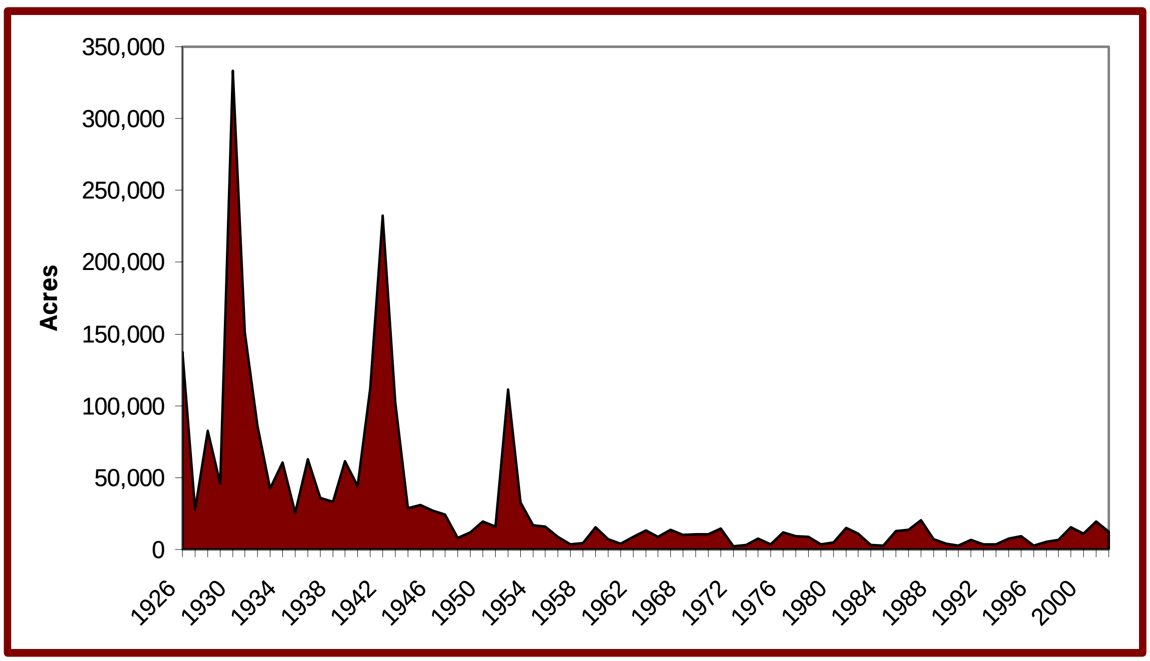
Figure 2. Forestland losses by county in the Tidewater RC&D 1992–1999 (U.S. Forest Service Forest Inventory Analysis Data, 2002).



Wildfire

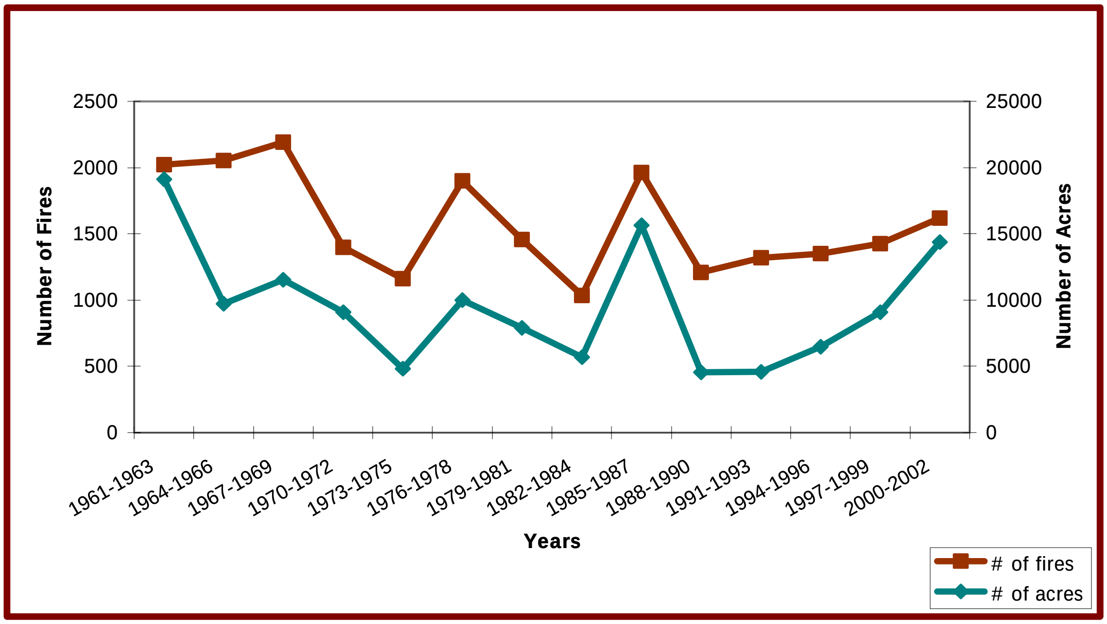
Wildfire is a natural phenomenon that occurs across many landscapes. In some forest ecosystems, wildfire is needed on many different levels. Without fire, forests build up debris, change animal habitat, decrease in species diversity, and are more susceptible to large catastrophic fires. It is society's view of wildfire as a negative experience that reinforces the perception that fire is something that should be controlled. As a result of this desire to control fires, the number of acres burned by wildfires in Virginia decreased significantly throughout the 20th century (Figure 3). This is due largely to our effectiveness in suppression and exclusion of fire. This dramatic decrease in acres of forestland being burned on a recurrent schedule increases the likelihood that larger, more catastrophic fires will occur because of increased fuel loads in forests. Larger, more intense fires can be more devastating because they are harder to control, can degrade soil quality, cause property loss, tree mortality, create air pollution, as well as destroy habitat for wildlife.

Figure 3. Acres burned by wildfire in Virginia 1925–2002 (Virginia Department of Forestry, 2002).



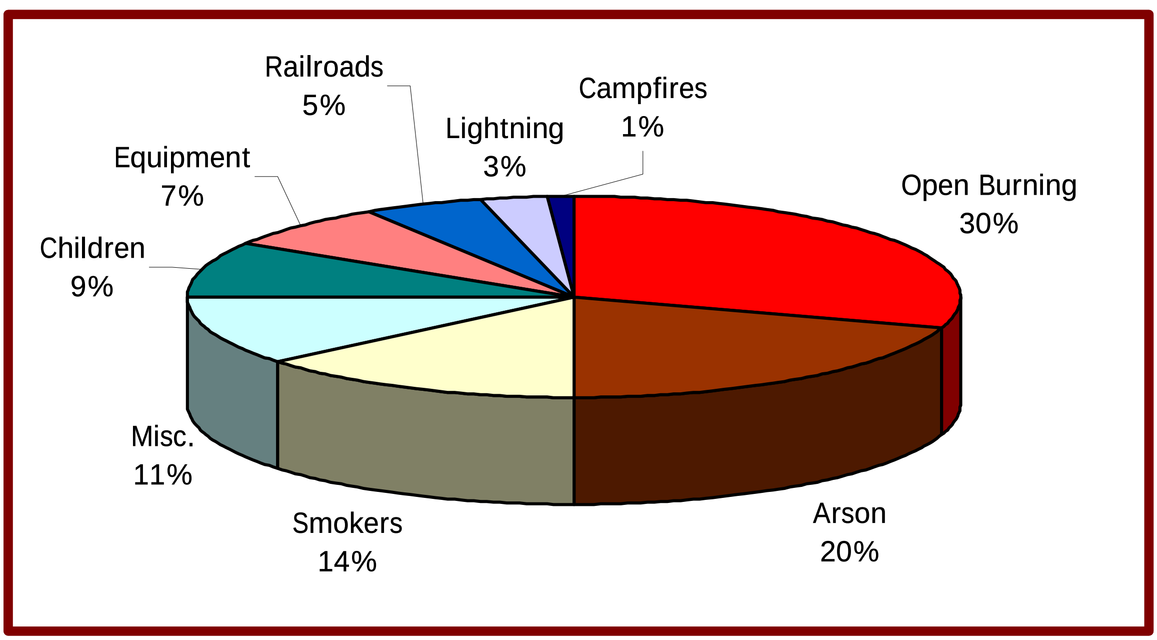
Throughout Virginia, there has been an increase in the number of wildfires and an increase in the size of those wildfires in the last few years. From 1994 to 1998, Virginia averaged 1,320 fires per year, and burned 6,081 acres (Virginia Department of Forestry, 2002). In 1999, the number of fires increased 33% to 1,749 fires, and the acres burned increased 99% to 12,118 acres (Virginia Department of Forestry, 2002). From 1999 through November 2002, 1,699 fires have burned 23,294 acres, a 92% increase in acres burned and a 3% decrease in the number of fires (National Interagency Fire Center, 2002; Virginia Department of Forestry, 2002) (Figure 4).

Figure 4. Average number of wildfires and average number of acres burned in Virginia 1961 – November 2002 (Virginia Department of Forestry, 2002).



Average annual wildfire occurrence in the Tidewater RC&D area over a 5-year period (1994 – 1998) is 32 fires per year, with an average size of 21.2 acres per fire (Virginia Department of Forestry, 2002). While the number of wildfires in the RC&D area is not very high today, the concern is the potential for wildfires to ignite and become much larger than in previous years. This concern is reinforced by the fact that managed forestlands are being lost to development and the largest cause of wildfires in Virginia is people (Virginia Department of Forestry, 2002) (Figure 5). As our population grows, we are seeing more people build homes in our woodland areas, which are natural fire environments.

Figure 5. Wildfire Causes in Virginia (Virginia Department of Forestry, 2002).



Forest Stand Types

The removal of wildfire from some landscapes has decreased stand diversity, altered stand species composition, limited nutrient availability, and has added to the chance of catastrophic wildfires (Spurr & Barnes, 1992). Fire's role in the forest for many years has been to ensure tree diversity and removal of dead or dying materials. Essentially, fire is needed to clean the forest floor of debris and open areas of the existing canopy for regeneration of new trees and species. However, as a result of fire exclusion, this is not happening. Losses of natural stands of Southern Yellow Pine, many of which benefit from fire, and losses in timberland acreages in the eastern United States are as high as 77% (South & Buckner, Journal of Forestry, January/February 2003). The loss of species diversity in our forests can contribute to the size, intensity, and devastation of wildfires. Reasons for these increases in destruction of forests are due to concentrations of tree species that are not adapted to fire environments and intense fires.

Solutions to the Problem

Possible solutions to the problems of population growth, fire, and forestland conversion are to heighten public awareness of forest management, forest health, and policy in these areas. We need to have increased utilization of materials, as well as increased awareness of the public about their responsibilities in wooded lots within the suburban/rural interface. People can approach a balance of suburban/rural living through firewise development, forest management, and increased utilization of forest materials. This approach will reduce risk and limit wildfire severity and intensity while establishing an economic market for low value timber and create jobs. While improved suppression techniques and communications have helped to extinguish wildfires; an effort to turn alternative forest products into an economically profitable venture is needed to ensure longevity of treatments and public safety. This review focuses on the utilization of the materials, and not necessarily the education concerning wildfire.

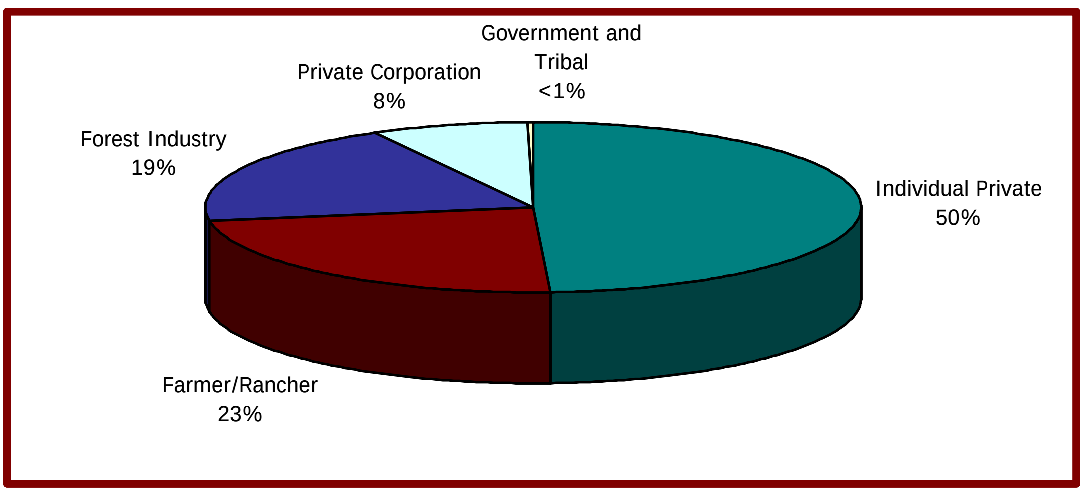
The Tidewater RC&D Area

Area Description

Land use within the Tidewater RC&D area is primarily forestry (62%) and agricultural (19%) (U.S. Forest Service Forest Inventory Analysis Database, 1992; Virginia Agricultural Statistics Bulletin and Resource Directory, 2000). Forestland ownership is broken into the following ownership classes: individual private, farmer/rancher, forest industry, private corporation, county government, state government, federal government, and tribal (U.S. Forest Service Forest Inventory Analysis Database, 1992) (Figure 6).

Figure 6. Forestland ownership's by acres in the Tidewater RC&D area (U.S. Forest Service FIA Data, 1992).

Ownership Class		Acres
Individual Private		400,000
Farmer/Rancher		188,500
Forest Industry		158,000
Private Corporation		63,000
Government and Tribal		3,200
County	*1,900*	
State	*800*	
Miscellaneous Federal	*100*	
Tribal	*400*	
TOTAL		812,700



Forest Description

Total forestland in the Tidewater RC&D area is 812,700 acres. Thirty-five percent is in the loblolly/shortleaf pine forest type (*Pinus taeda/Pinus echinata)*. Of this forest type, 54% is planted and 46% is natural regeneration. The remaining 65% of the forestland is a mixed oak/pine/hickory forest type (Figure 7). Fifty-five percent of the forestland base is categorized as poletimber (12 inches and smaller) or below, with saw timber (12 inches and greater) making up the remainder (Figure 8).

Figure 7. Total area of timberland in acres by cover type and regeneration method in Tidewater RC&D (U.S. Forest Service Forest Inventory Analysis Database, 1992).

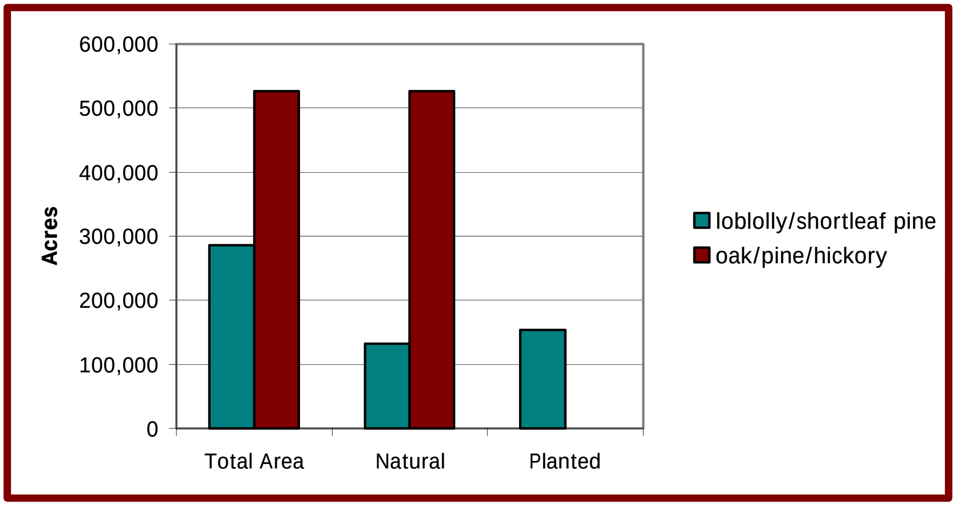
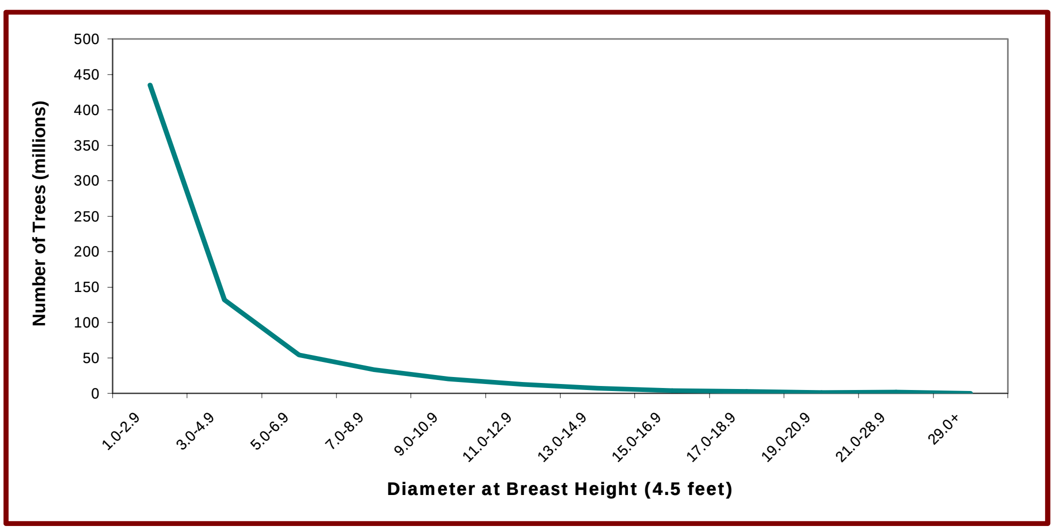


Figure 8. Diameter distribution in the Tidewater RC&D area (U.S. Forest Service Forest Inventory Analysis Database, 2002).



Ownership of forestland by forest type can be characterized as 80% privately owned and the remaining 20% owned by forest industry. The majority of the private land is hardwood (71%), while the industry land is primarily softwood (61%) (U.S. Forest Service Forest Inventory Analysis Database, 1992).

Small Diameter Timber (SDT) and Low Value Materials

In the forests of eastern Virginia as well as across the nation, there is an abundance of timber materials that currently have little or no market value in traditional timber markets. These materials are often small diameter and low quality. Most forests have a high proportion of small diameter trees and many unmanaged or poorly managed stands are comprised of low value materials because of age, species, shade tolerance, origin, and site quality. As a result, small diameter timber and underutilized material are creating problems with forest health, stand diversity, proper forest management, as well as wildfires (U.S. Forest Service, Pacific Northwest Research Station, 1998).

Small diameter and low value timber typically have been left on site as debris, open burned, hauled to a landfill, or chipped for paper or fuels. More often than not, the undesirable material is left in the timber stand after harvest to grow. This practice in turn creates or perpetuates poor quality timber stands for the future. These materials are underutilized mainly due to the low value returns on their harvest and the high cost of removal and transportation.

Harvest intensity of low-grade, small diameter trees has the greatest influence on the profitability of each harvest (Kluender, et al., 1998). The larger the volume harvested and the greater the efficiency at which the trees are harvested, the greater the opportunity to realize a profit. Harvest costs per acre tend to decrease as tract size increases. Although a profit can be realized with small diameter timber, the margin for profit is significantly lower when compared with the harvest of higher grade, larger diameter trees. This gap in the economics almost always ensures that the overstocked small diameter stands are left, while larger diameter, less-risky ventures are pursued. Existing markets and current prices are also major contributors. This presents an interesting problem when dealing with converted forest industry lands, small parcels, over-stocked stands or residential areas where partial volume removals for development will be common.

Kluender, et al. found that if skid distances and load sizes are held constant, tree diameter is the leading factor in the cost per volume unit harvested. The study also showed small diameter material had the greatest increase in value with the number of stems harvested than with other product classes. To combat the potential for low returns and forest health declines, value-added uses of the small diameter timber must be emphasized.

To illustrate the potential for returns on this material here are two situations.

The first is an open pine stand being cleared in acre lots for homes that will have higher volumes and lower harvesting costs ($200 per acre) (Table 1). The second is an area that is occupied by homes and fuel reduction activities are taking place around the community (post construction) that will have lower volumes removed (approximately 50% less) and higher harvesting cost ($300 per acre) (Table 2).

The current average market price for pine pulpwood stumpage in the Southeast is $6.24 per ton (Timber Mart-South, 2002), and the average area gatewood price is $22.00 per ton (local contact, 2003). Average harvesting costs are approximately $150 – $500 per acre (U.S. Forest Service, 2000). Mean transportation costs in Virginia are approximately $2.00 per ton with an average haul distance of 40 miles (Becker, Personal Contact, 2003). To place these numbers into context, see Tables 1 and 2.

Table 1. Potential revenue generated for harvesting one acre of a 15 year-old Southern Yellow Pine plantation in Virginia *(Pre-Construction)*.

Payment per Ton (Gatewood–Stumpage)	*Average Production Rate per Acre x Revenue	Low End Harvesting Cost per Acre***	**Average Cost per Ton for Hauling	Total Revenue per Acre
$22.00 - $6.24 = $15.76	60 tons x $15.76 = $945.60	-$200.00	- $2.00 * 60 = $120.00	= **$625.60**

Table 2. Potential Revenue Generated for Thinning Fifty Percent of the Volume of a One Acre 15 Year-old Southern Yellow Pine Plantation in Virginia *(Post Construction)*.

Payment per Ton (Gatewood–Stumpage)	*Average Production Rate per Acre x Revenue	High End Harvesting Cost per Acre***	**Average Cost per Ton for Hauling	Total Revenue per Acre
$22.00 - $6.24 = $15.76	30 tons x $15.76 = $472.80	-$300.00	- $2.00 *30 = $60.00	= **$112.80**

**Average production rate per acre of 15-year-old Yellow Pine Plantation in Virginia (Virginia Department of Forestry, 2003).*

*** Average cost per ton for hauling based upon a 40 mile haul distance (Virginia Department of Forestry, 2003).*

**** Average harvesting costs (U.S. Forest Service).*

----*"Stumpage" is the price that is paid to a landowner for standing timber usually by a logger.*
----*"Gatewood" is the price that is paid to the logger usually by a processor.*

Current Timber Products and By-Products

Uses of forest products are almost always geared toward what will generate the largest profit. Consequently, lumber and specialty products are the most widely accepted markets and utilize larger, higher quality logs. The small diameter, low value wood that this review is referring to typically does not lend itself to these higher quality markets. The reasons for this are almost purely economic. Ways to increase profits are to reduce harvesting overhead, lower hauling costs, have increased volumes removed from a site, or discover uses for material that will increase value. The purpose of this review is to identify the value-added uses for materials that are typically regarded as cost prohibitive. This will benefit forest health, economics, and community safety.

Currently, the number of primary producers (sawmills) in the Tidewater RC&D area total 16 (Virginia Department of Forestry, Primary Producers Directory, 2001). The current timber products are primarily dimensional lumber, pulp and paper, pallets, and some value-added industries such as mulch, treated posts, and poles. These products sometimes use low value materials but do not focus specifically on the value-added utilization of small diameter timber or low value materials. The pulp and paper industry consumes the majority of the small diameter and low value timber.

Uses as represented in the Virginia Department of Forestry 1998/1999 tax receipt data show stumpage values of pulp and saw logs in the ten counties to equal $30,516,615. The majority of the products are pine, which equals 79% of the total stumpage value with $24,170,805. Hardwood stumpage equals the remaining 21% with $6,345,502 (Virginia Department of Forestry, 1999). The majority of the market share is from saw timber (10”+), which comprises over 122 million board feet (Virginia Department of Forestry, 1999). The 2002 Forest Products Tax receipt data shows a sharp decline (38%) in overall revenues in the ten counties since 1998.

If industry and rural entrepreneurs could capitalize on the addition of low value hardwood, and small diameter pine, the potential for market growth could cause these figures to rise.

Potential Products

Potential product markets that exist within the Tidewater RC&D area are not restricted to those discussed here. However, based upon fuel reduction activities, economic climate, raw product availability, and current infrastructure, these markets are perceived to be feasible. Products are arranged in an order of complexity. First, the more complex, more labor intensive industries with the highest initial investments, then the least complex, least labor intensive and lowest initial expense will follow. Examined will be the primary manufacture of products and their uses, followed by a secondary use. The secondary use is an additional step in manufacturing but adds to the value of the finished product and can be considered a logical next step.

Engineered Wood Products (EWP)

Engineered wood products are a growing segment of our wood products industry and can use both low value and small diameter materials. The benefits of using engineered products over natural wood are that they can equal or exceed some of the strength and structural properties that make natural wood desirable as a building material. They can also use the lower grade and smaller trees. The strengths and structural characteristics can be achieved by combining, reorganizing or stratifying the product’s elements (Youngquist, 1999). Consistency within the material and the processes of manufacturing also allow for a more uniform and predetermined product with desirable applications over natural wood counterparts that will have variations (Youngquist, 1999). These manufactured products consist of taking various sized wood particles and combining them into a structurally consistent, predictable, solid wood product. The manufacturing process is done through applying pressure, heat, glue, or a combination of these methods. For simplicity engineered wood products will be broken into three categories: the structural composite lumber, the panel products, and the wood/non-wood composites.

Structural Composite Lumber

Structural composite lumber products are primarily made from roundwood that has been through a process of chipping, flaking, or chunking into a predetermined size or into various sized pieces. These pieces are then oriented and combined through an adhering process. The adhering process consists of taking the raw materials and gluing, fusing, compressing, or otherwise reshaping them into a much larger conglomerate that can be used in various construction applications. The conglomerates are formed into sizes that are common for solid-sawn lumber (Moody, et. al). These products include parallel strand lumber (PSL). PSL is a composite of wood strands (approximately 2 feet long and ¾ inch wide) with the fibers oriented along the length of the lumber and is compressed using a waterproof adhesive. Other products that are made with similar processes are laminated strand lumber (LSL), and oriented strand lumber (OSL). These products will potentially compete with sawn lumber in the dimensional lumber market.

Panel Products

It should be noted that some of the high value panel products cannot be manufactured using small diameter timber (plywood, laminated veneer lumber). The high value products that need to utilize the larger diameter, high value trees are associated with some fuel reduction sites but will be less common than the small diameter, low value trees. However, there are panel products that can be manufactured using roundwood and chips from low value timber. The U.S. Forest Service Forest Products Laboratory places panel products into five main classes: plywood, oriented strandboard, particleboard, hardboard, and cellulosic fiberboard. Youngquist defines the products as follows.

Plywood is a flat panel constructed of sheets of veneer called plies. The plies are united under pressure using a bonding agent to create a panel. The sheets are constructed with an odd number of layers with the wood grain being oriented perpendicular to the adjacent layers. The grain of the outer layers or the "face and back" of the sheet are generally oriented parallel to the long dimension of the panel. Some of the benefits of plywood are the laminated construction distributes the defects, reduces splitting, and increases structural stability.

Secondary

Other value-added uses of plywood also exist in many areas. After manufacture, plywood can be treated with a fire retardant for use in public construction projects like hospitals and schools or can be pressure treated for marine applications for boathouses or outdoor sheds. Availability of volumes of high quality trees to ensure the stability of a plywood and laminated veneer lumber (LVL) operation in the Tidewater RC&D area need to be evaluated further.

Laminated veneer lumber (LVL) is much like plywood, except it is composed of layers of higher quality thin veneers (thinner than plywood plies) that are hot pressed together with an adhesive with all plies orientated parallel to each other.

Oriented strand board (OSB) is an engineered product that is assembled using strips of wood that are flaked or chipped from roundwood. Similar to plywood, these strips (generally .5 x 4 – 6 inches) are layered and bonded perpendicular to each other. Typical uses for OSB are construction of roofing, wall and floors in residential and commercial developments. This product is a growing segment of the housing construction market due to the higher expense and the quality of timber associated with manufacturing plywood (Figure 9).

Fiberboard, which can include hardboard, medium density fiberboard (MDF), and insulation board, is a panel product that is similar to OSB. The major difference is that it utilizes much smaller tree materials (fibers). Originally designed to use the manufacturing by-products of other wood product industries (sawdust, planer shavings, mill residues), wood fiber has found a niche in today's market. Fiberboard accentuates the basis for most engineered wood products by using the wood fibers. These fibers are exposed either by a mechanical process of grinding, water soaking, or chemicals. The board is then manufactured using a method much like the paper making process, except on a larger scale. The fibers are laid in either a dry or wet state on a belt and compressed into a dense product. Typical uses are in furniture, cabinets, and insulation.

Particleboard utilizes a layering manufacturing process much like the products listed above with exceptions. One of the exceptions is that the raw material is larger. Particleboard does not use the fibers; it utilizes splinter size materials. Upon completion, the faces of the finished board are smooth and can be used in a variety of ways. Common uses of particleboard are in furniture, speaker cabinets, interior doors, moldings, trim, pre-finished house siding, and appliances.

Figure 9. Examples of Some Panel Products (APA The Engineered Wood Association).

Secondary

Additional processing can produce prefabricated wood I-joists (Figure 10). Prefabricated I-joists are products that can be constructed from the materials discussed above by including an additional step. The I-joists are made using high grade solid or composition lumber as flanges and a sheet of structural composite panel as the web. The components are then glued with a waterproof adhesive in the grooves in the dimensional lumber. The benefits of this type of material that they are lightweight, stable, and uniform. The Prefabricated wood I-joists are used in flooring and roofing applications.

Figure 10. Manufactured Wood I-Joists (APA The Engineered Wood Association, 2003).

Estimated Costs of Engineered Wood Products (Structural Composite Lumber and Panel Products)

In "Industrial Development Opportunities For Wood Products in Virginia," Kamke suggests that under the current OSB practice, the smallest plant that could be economically feasible would produce approximately 90 million square feet of wood per year (1990). He also states that the investment for a plant this size (in 1990 dollars) is approximately $35 million. The return on this investment is around 5 – 10%. An engineered wood product I-beam plant which uses OSB webbing and hardwood flange would require a $5 million investment, use about 25 million square feet of OSB per year, employ 85 people, and have an estimated return of 25% (Kamke, 1990).

Comparisons between these engineered wood products and their solid wood counterparts in the marketplace show that a growing share of the market is moving towards engineered wood products. Engineered wood products allow for a more efficient use of trees and can also utilize the fast growing, once undesirable trees (APA, 2002). Between 1980 and 1994, growth in the North American structural wood panel production increased from 19.3 billion square feet to 32.6 billion square feet (Forestworld.com, 2002).

Wood and Non-Wood Composites

This product is driven by three main goals. First, reduce material costs by combining cheaper materials with expensive materials (fillers). Second, develop products that can utilize recycled materials. Third, produce composite products that can exhibit specific properties that are superior to those when used alone (Youngquist, 1999). The use of wood flour, fibers, chips, and dust in combination with concrete, gypsum, plastics, and other materials produce such diverse products as interior and exterior building components, automobile panels, drywall, and signage (utilize recycled plastics).

The composite sign products are a realistic "mom and pop" venture within the engineered wood product industry. The signs consist of taking a 50/50 mixture of recycled thermoset plastic and wood fiber/flour/particles. Its primary purpose is to offset the cost of thermoset plastics. The wood texture and size depends upon the finished product use. The process is commonly done by melting recycled plastic, combining this with wood particles and other materials and then pouring the mixture into forms and cooling. After cooling, the slab can be routed, painted, shaped etc. into many different forms. The benefits of composite signs are they are cheaper than most current sign materials (about $^{1}/_{3}$ to $^{1}/_{6}$ the cost of pure plastic), use recycled materials, are less susceptible to predation by animals, and are easy to repair.

A business venture such as manufacturing composite signs can be as industrial and as expensive as other engineered wood products listed above or a very simple, fairly inexpensive garage operation. This will depend upon the owner's desire. The industrial mass production capabilities requires an initial investment of around $600,000 – $750,000 for used equipment and an additional cost for buildings, etc. (Forest Products Laboratory, Personal Contact, 2003). This industrial process (simplified) includes a chipper, a hammermill, extruder, forms and a cool water bath. The small business owner can adapt this by purchasing or collecting the plastic containers and the desired wood substrate, heating to the required temperature (375°F), constructing their own forms, pouring the material by hand, and allowing it to either air cool or spraying with water.

All of the products mentioned have fluctuation in costs when compared within each category and to each other. Raw material availability, transportation, overhead, size of facility, mechanized or skilled labor, and complexity of process all contribute to the cost differences.

Biofuels/Wood Heat

The idea of utilizing fuelwood goes back to the introduction of fire itself. In 1850, fuelwood represented about 91% of the total energy supply of the U.S. (Bain & Overend, 2002). During the 1970's energy crisis, many alternatives to fossil fuels were researched in order to prevent the likelihood of such an incident from occurring in the future and renewable energy sources were considered.

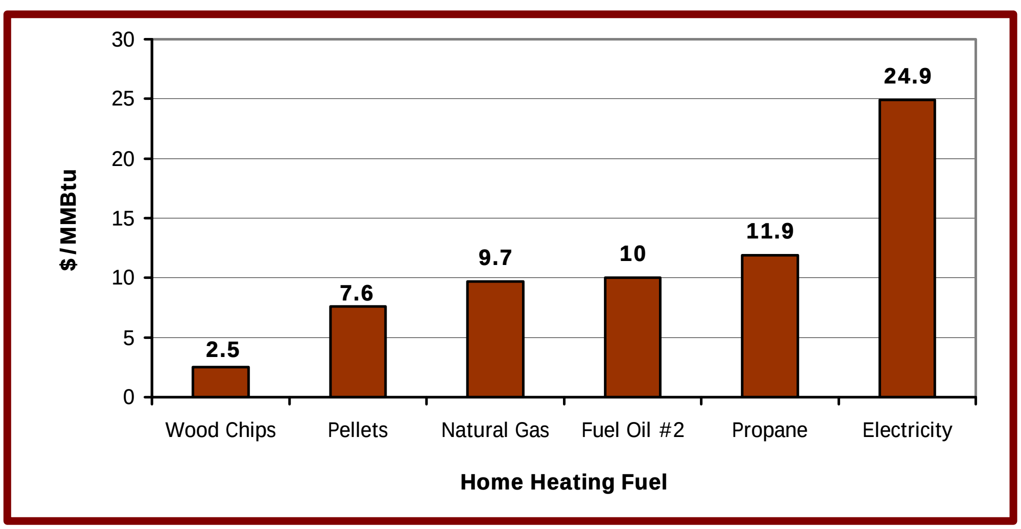
Presently, biopower is a proven commercial electricity generating option in the United States, and is the single largest source of non-hydro renewable electricity (Bain & Overend, 2002). Environmental benefits of biofuels include their renewability as a resource, and they contribute no net production of carbon dioxide (the major greenhouse gas). They do not contain sulfur or heavy metals, which limits their contribution to acid rain. Their particulate emissions are easily controlled and the ash by-product can be used as a fertilizer (Bergman & Zerbe, 2001). Virginia Power currently lists seven biomass power-generating facilities within the state and one in North Carolina. The earliest of the facilities to go online in Virginia was Westvaco, in Covington in 1980 (VEPCO via Connective Energy, 1999).

The main reasons why the use of biofuels increased were the availability of the raw materials, the use of manufacturing by-products residues, and an increase in the efforts of the pulp and paper industry to become more energy self-sufficient (Bain & Overend, 2002; Zerbe, 1988). Woodfuels also have the potential to create national energy security (through independence) and are not as subject to the price fluctuations that are common to fossil fuel markets (Bergman & Zerbe, 2001).

Current uses of woodfuels in the RC&D area exist primarily in forest industry. Local primary producers use chips and sawdust to fire boilers to heat kilns to dry lumber. Pulp and paper mills use chips, slabs, and waste material to create energy for their own use, while selling the excess energy produced to local power companies. Advances in the burning technology of cogeneration can also reduce the use of fossil fuels by increasing efficiency of fuelwood (Bain & Overend, 2002).

Cost comparisons between woodfuels and fossil fuels can vary (Figure 11). Commonly, the cost of woodfuel depends largely upon supply and demand due to the large quantities needed. Costs of woodfuels are also highly dependent on transportation fees. Typically, the average cost of fuel wood is the average cost of pulpwood for a given area (Bergman & Zerbe, 2001).

Figure 11. Home Heating Fuel Comparisons per Million British Thermal Units (MMBtu) (Bergman & Zerbe, 2003).



Secondary

A common way to increase the value and efficiency of woodfuels is to manufacture them into a compressed pellet. Used both by the residential and industrial consumers, wood pellets are a growing industry not only in the U.S., but also in many other countries around the world (Pellet Fuels Institute, 2002). For example, Sweden and Denmark both imported 100,000 tons of wood pellets last year (Nielson, 2002). The residential pellet market is a key player in utilizing the hardwood component for home heating. There are some industrial uses for softwood pellets or a combination of hardwood and softwood, but the major markets currently lie in hardwood residential use. Hardwood is favored over softwood due to its higher heat output, and less maintenance and cleaning of burning equipment is required because of a lower ash content. Other benefits of using woodfuels in pellet form over other woodfuel types are that pellets burn more intensely, are easier to handle, package, and ship than chips or chunk fuel.

The Pellet Fuels Institute reported a 14% increase (89,000 tons) in U.S. pellet fuel sales from 2000 to 2001, while total pellet appliance shipments increased 48% in 2000 (12,000). Currently there are 730,000 tons of pellets and 37,000 pellet burning appliances sold annually in the U.S. (Pellet Fuels Institute, 2002).

The pelletizing process rescues wood from being burned in open air fires, decreases the amount of wood waste in landfills (6.5 million cubic yards in 1993 – 1994) and reduces air pollution (Pellet Fuels Institute, 2002). Equipment and the process needed in order to take raw material to pellet form in eastern Virginia are:

- Kiln or dryer, grinder, chipper or a high torque shredder to reduce the size of material which is then placed into a hopper to store the material;
- From the hopper, the material is moved via a conveyor system into another hopper, along this line a magnetic system is incorporated to remove metal objects;
- From this hopper, the reduced material is loaded into a hammermill to further reduce the material into a powder (wood flour);
- The powder is placed into a hopper above a pelletmill;
- From the pelletmill, the pellets are loaded into a cooler/dryer;
- The pellets are then loaded into another hopper and bagged.

What makes this opportunity appealing in the Tidewater RC&D is the availability of raw materials, low start-up cost ($500,000 – $1,000,000 (for a commercial operation)), increasing demand for pellets, and currently there is only one pellet manufacturing facility in Virginia (Pellet Fuels Institute, 2002). Bulk retail prices in the area average $120 – $177 per ton.

Firewood

Due to the high proportion of low quality hardwood that can be expected during fuel removal, one must evaluate the firewood markets. During most harvesting operations, low value hardwoods are commonly left standing on site or are felled and remain on the forest floor as slash. This unwanted material will be removed or processed with site preparation techniques before the next planting. However, this material is sometimes left in piles on landings and is often sold at low cost, given away, or burned on site. This increases the opportunity for free or low cost materials to be bucked, split, and packaged as firewood. Because of the relatively low capital investment with this endeavor, the possibility of a high profit margin exists.

Minimum equipment needed to begin in this market (with some mechanical dependence) is dry wood, a chainsaw, splitter, and a firewood packaging system. Cost of this equipment varies, but here are a few examples. Professional quality chainsaws typically range from $350 to $575 (Husqvarna 2002; Stihl, 2002). Wood splitters come in many different grades. If production and portability are the main objectives, then a commercial splitter that produces 1 cord per hour will cost $16,995. A portable, manual feed splitter with a 5 HP motor runs about $1,095. In between these two extremes, are commercial/professional grade portable splitters that are comprised of 11 HP motors and have either 22 or 30 tonnage of force and cost $4,995 – $5,195 (Baileys, 2002). Firewood packaging units range in cost from $1,995 (produces 50 – 60 bundles per hour) to $23,500 (produces 700 bundles per hour) (Mountain Valley Manufacturing, 2002, B&B Manufacturing, 2002) (Figure 12).

Figure 12. Packaged Firewood Bundle (Courtesy of B&B Manufacturing).

In the Tidewater RC&D area, a cord of firewood (4'x 4'x 8' or 128 cubic feet) commonly sells for $80 – $100 unpackaged. Considering a wholesale market, within a cord, there are approximately 170, $^{3}/_{4}$ cubic foot packaged bundles of wood. Bundled wood wholesale prices can average $2.00 to $2.75 per bundle. Average cost of materials are $.13 per bundle for materials, $.25 per bundle for labor ($12.50 per hour), and $.20 per bundle delivery (B&B Manufacturing, 2002). This equates to $241.40 per cord at $2.00, and $368.90 per cord at $2.75. Potential markets for this material are campgrounds, convenience stores, fundraisers, etc. The potential for these markets to exist in our area need to be further researched.

Sawn Products

Dimensional Lumber/Cants

A driving factor in determining whether or not the dimensional lumber market can or should be pursued is the pulpwood market. If pulpwood prices are high enough to generate the desired return, then the amount of processing and handling of the pulp will be much less than the cost to manufacture lumber. If pulpwood prices are substandard, then a value-added use should be determined. One of the main challenges in trying to utilize small diameter timber as **dimensional lumber** is the accuracy needed to saw the log into a profitable product (U.S.F.S.; Forest Products Lab, 2000). Without increased lumber recovery and good decision making at the saw, time, product, and money are wasted. It is also difficult to saw enough quality dimensional lumber from the small diameter timber (SDT) to justify the time, expense, and the opportunity cost that is lost to not sawing larger logs.

A way to increase the potential of recovery and extend profits of the SDT is to use a portable sawmill. Advantages of portable sawmills include: a much lower capital investment than a typical stationary mill, requires only one or two persons to operate, and it can have more time allocated to sawing special cuts and specialty products. Standard portable sawmills can cost between $80 for a chainsaw driven mill to upwards of $50,000 for pickup truck drawn models. There are also portable, high volume, small diameter sawmills available. One example of this type of mill is the Micromill from Micromill Systems Inc. Their mill specializes in small diameter logs that range from 3 to 13 inches in diameter, and from 5 to 20 feet in length. The mills come in two different versions, diesel and electric, typically costing between $300,000 and $450,000. Production rates on the mill are around 25,000 to 100,000 cubic meters per year. What separates these mills from the standard portable mills is their ability to recover more dimensional lumber quicker by processing a whole log in one pass.

The benefit of using either type of portable sawmill over a stationary mill is that the use of a portable mill limits the transportation costs of hauling the low value and small diameter timber by bringing the equipment to the site. This technique can increase profits because set up and transport of the mill is cheaper (within certain distances) than the loading and transport of products to a stationary mill. Another benefit of the portable mill is they can offer a smaller kerf, which increases lumber recovery. When sawing boards with ban saws or with thin kerf circular saws, the operator is able to increase the amount of wood recovery possible in each pass by limiting waste in the form of saw dust. Because of the potential production rates, size and mobility, the saw could be ideal for small woodlots, small crews, and fuel reduction work.

Secondary

Value-added uses of sawn material are numerous. Lower quality lumber can potentially be used in some interior furniture components, construction of outbuildings, cabinets, as well as pallets (Figure 13). Cants can also be used in pallet manufacture for skids, rustic posts, and small fencing projects. Species will be a determinant in which product can be manufactured. Species such as eastern red cedar and locust can be used in the fence and landscape market while others like southern yellow pine must be treated before use in this arena. This adds another expense to the product and warrants the need for a higher price. Another secondary treatment to increase returns on lumber is drying. Kiln drying lumber can increase the processing cost but will also increase value as well. Due to the products' initial low value, it is difficult to recover cost and turn a profit with any added expenses. However, advances in low-cost drying could limit financial loss, and increase recovery of lumber within the kiln (Levan-Green & Livingston, 2001). Small diameter timber lumber, whether it is hardwood or softwood, does not necessarily need to be kiln dried; but quantity and quality of lumber recovery has been shown to increase with kiln drying compared to air-drying.

Figure 13. Interior Furniture Components (APA The Engineered Wood Association, 2003).

Flooring / Log Cabin / Molding

The attractiveness of the flooring/log cabin/molding market is the ability to produce diversified products from one piece of equipment. This will decrease processing costs. Markets that can be utilized with the purchase of a planer/molder are wood flooring, custom molding for remodeling jobs and renovations, unique molding for new construction and log cabin logs. A single person operation or a more extensive approach are feasible.

Investment needed to begin in this market range from $750 to $100,000 for the planer/molder (Logosol, TimberKing, Auburn Machinery, 2002). As with most of the equipment being considered within this review, machine complexity, production and reliability have a large effect on the initial investment. The JET JPM-13CS machine which produces 10 feet per minute (molding) and 20 feet per minute (planing) sells for $799.95 (JET, 2002). The TimberKing BIG 18 produces up to 16 feet per minute and sells for $3,151.45 – $3,845.45 (TimberKing, 2002). The Logosol PH260 4-head Planer, which can produce from 8 to 48 feet of linear trim per minute sells for $7,995 (Logosol, 2002). In contrast to those, is the Auburn Pinheiro, 600 Series that produces 30 to 60 feet per minute sells for $50,000 and its larger counterpart, the 1000 Series produces 20 to 230 feet per minute and costs $100,000 (Auburn, 2002). Special order and custom work is a market that may see substantial increases in profit over standard order materials. As a general rule, price increases as product size and quality increases (Floorings.com, 2002).

Unsawn Material

Landscape Timbers / Fence Posts

Small diameter, low value yellow pine timber has many uses. These uses include fence posts, flower and tree box construction, pond walls, and retaining walls. Treated small diameter timbers are relatively inexpensive and easy to use when compared to more labor-intensive products. Production of these materials consists of cutting to length, debarking, peeling to a uniform size, and drying.

Investment into this is market is nominal (less than $30,000). An individual can begin in this market with the purchase of an 18 HP tractor and a portable PTO peeler combination unit. Estimated costs of these two pieces of equipment are $4,995 for the peeler (Scandinavian Forestry Tech, 2002), and between $11,000 – $13,000 for the 18 HP tractor (John Deere & Massey Ferguson, 2002). Portable electric, diesel, or gas models are also available for the peeler and range in expense from $5,595 to $10,000.

Secondary

A secondary finishing step that adds value to these materials and expands their use is the current acceptable process of using CCA (Chromated Copper Arsenate) to treat the wood. The down side to this type of treatment is that there is a cost associated with the application to the small manufacturer. CCA treatment is typically done at certified, monitored, and approved facilities. The up side is the treated wood's resistance to insects, rot, and disease, which increases desirability and potentially increases profit. However, the CCA treatment of wood may soon be removed from residential use (Environmental Protection Agency, 2002). There are many different types of wood treatments that can be used other than CCA. "Mom and pop" operations can use treatments such as borates and copper naphenate that they can apply themselves.

One alternative treating method of ACQ (Alkaline Copper Quarternary) is expected to cost anywhere from 7 – 30% more than CCA and needs to be applied by a certified facility. Approximate costs for treating pole material are dependent upon several factors: minimum moisture content (25%) of the wood, species, diameter, and length. Typical cost of treating a 4 – 5 inch, 8-foot pole with CCA is around $2.20 each (local contact, 2002). Estimated costs of treating pole material with ACQ are anywhere from $2.35 to $2.86 each.

Roundwood

To limit the impact of milling decisions for sawn material, using small diameter timber as roundwood in building applications is the most lucrative (Stern, 2001). Stern suggests the most profitable uses of roundwood are in structural and non-structural systems (Figure 14). These include roundwood framing, trusses, half-round siding, railings, and rustic furniture. The advantages of using this material in roundwood form are that it is durable, less susceptible to warp, dimensionally stable, stronger than most lumber that is sawn from it, and processing costs are low (Levan-Green & Livingston, 2001). One of the challenges in determining the success of these products is changing the perception of the use of these materials by designers, architects, and engineers.

Minimum processing requirements for this product are delimbing, peeling, cutting to length, and drying. Currently, there are many U.S. Forest Service studies and pilot construction projects being conducted across the United States using this roundwood in a structural capacity. Applicability of this product in eastern Virginia needs further research.

Figure 14. Roundwood Used as Structural Building Material (Courtesy U.S. Forest Service).

Wood Excelsior

Wood excelsior, although typically hardwood shavings or peelings, can be made from any type of wood. Historically it has been used as protective packaging for shipping and animal bedding. This material is still used as such, but also has new applications within today's heightened environmental climate.

Erosion control mats (ECM) that are constructed from excelsior are used to reduce erosion by creating soil stability until vegetation can be established on a sensitive site (Figure 15). Typical uses of ECM are roadsides, landfills, ditches, spillways, shorelines, embankments, and moderate to large landscaping projects (Shepley, et. al. 2002). Biodegradable wood excelsior can be used in erosion reduction capacities, shipping and packaging applications as well as decorative uses when colored.

Figure 15. Excelsior Erosion Control Mats Used in Highway Application. (Photos from Erosion Control Technology Council, 2002)

In erosion control applications, the wood peelings are held together with netting or mesh, and sold in rolls as blankets (Shepley et al., 2002). Other uses for the excelsior are as sediment trapping logs for ditches, stream bank erosion control, etc. Manufacturing costs of these products vary; common selling prices for the material is subject to large variances due to supply and demand. Shepley et. al., reported that wood excelsior mat has sold wholesale for $.35 to $.85 per square yard.

Current market conditions for the product appear to be broad. With population growth and new construction on the rise into the near future, demand for erosion control should increase. Shepley et. al., reported that in 1998, the total sales volume for erosion control products was $225 million.

Mulch

Mulch is a feasible product that can be made from small diameter material, as well as low value, poor quality stems that are commonly associated with fuel reduction activities. Both hardwood and softwood can be utilized within this market, and tree size appears to be of no significant consequence. Tree tops, limbs and even stumps can be used. The manufacturing process for this product is relatively simple, and can have a low capital investment. However, the more complex the product, or specialized the product, the more specific the process and the higher the costs involved. Dyed mulches (typically recycled pallets or barkless wood), mulches with pesticide or fertilizer additives etc. do increase manufacturing costs, but also bring a higher rate of return in the marketplace. Using the fines from the mulching process can also be used in compost and as potting soil filler.

In the simplest application, an individual can purchase a small manual feed chipper (80 – 125 HP, 12" diameter) for around $20,000 – $30,000 (Arbor Recycling Equipment Company, Personal Contact, 2002). A small portable tub grinder (170 – 174 HP) with a production rate up to 85 yards per hour, is estimated at around $74,000 (Morbark, 2002). Approximate costs of a mulch color adding machine with production rates of 70 – 225 cubic feet per hour are about $40,000 – $70,000 (Amerimulch, 2002).

Common cubic yard prices for these materials in the market place vary. These price variances can be attributed to species, quality of the materials, and hauling distance. Another contributor to the cost variance is whether or not the product is being sold in individual units or in bulk. Hardwood mulch generally garners a higher price than softwood, and size of material (fine or course) also plays a large role in determining price. Current retail prices in the area are around $17.00 per cubic yard in bulk, and $2.99 per bag (3 cubic ft) (Figure 16).

Figure 16. Examples of Dyed Mulch (Courtesy Amerimulch, 2003).

Bedding/Farm Uses (wood shavings)

Animal bedding for large animals, as well as for small caged animals such as hamsters, rabbits, etc., is a growing market in Virginia. Other typical wood shavings product uses are nursery stock mulch, weed suppression, ground cover at outdoor events, wholesale packaging for frozen meats, and in the manufacturing of oriented strand board (OSB). The wood shavings market is increasing due to the ease of use, increased availability, absorption capabilities, and the low cost of materials and freight. Species most commonly used in the wood shavings markets are softwoods. Southern yellow pine, aspen, cottonwood, and other lightweight non-resinous woods are most desirable because of their ease of processing, availability, and moisture content.

A package (bale) containing 9 cubic feet of material can be compressed into a bag almost one third that size (SBS Wood Shavings, 2002). The 3.5 cubic foot bales can weigh anywhere from 30 – 50 pounds depending on moisture content. Bales that contain 8% or less moisture (30 lbs), can absorb up to 4 times their weight in moisture (DryNest, 2002). Equipment needed to begin in this venture is relatively simple, but complexity and cost increases as processing grows. Base prices for shaving mills that produce 150 – 200 cubic feet per hour cost around $30,900. These mills can handle 2 – 12 inches in diameter 2 – 4 foot bolts. For a mill that can produce 300 cubic feet per hour of shavings and can handle 2 – 24 inch diameter 3 – 4.5 foot bolts, costs are approximately $46,550. Mills that can produce large volume of shavings (500 cubic feet per hour) and can handle up to 24 inch diameter 8.5 foot logs runs about $64,220 (Jackson Lumber Harvesters, 2002).

Market prices for the finished product do vary. Individually priced units will generally bring more profit to an individual than bulk. Current retail price of 3.5 cubic foot bales in our area are $4.99 (Personal Contact, 2003). Product quality, transportation distance and market demand will also be major contributors.

Other Valuable Secondary Manufacturing Ventures

Furniture

Hand crafted furniture has been in existence in Virginia for centuries. Because of this longevity and because of the availability of small diameter timber, this opportunity must be evaluated. Two types of furniture will be reviewed. One is rustic furniture (Figure 17), which needs very little processing and the other is taking the processing of the material one step further, and utilizing rough cut dimensional lumber. In the manufacture of rustic furniture, some of the same tools are needed as mentioned in the previous sections but the process is much more simplified. The basic construction principles behind rustic furniture are the mortise and tenon. Equipment needed to produce the furniture in quantity and in a timely manner are a post peeler, a post and rail processor, and a post sander. Average amount of investment to approach this market ranges $30,000 – $50,000.

Assuming that the manufacturer is using rough cut dimensional lumber, the basic equipment required to create furniture are a cutoff saw, a miter saw, a joiner/planer, router, sander, table saw, a drill, various hand tools, and a finishing nailer. Total costs of these tools vary greatly and are attributed mainly to the quality of the tool. Performance and accessibility of these tools are proportional to cost. According to a survey conducted by the Unfinished Furniture Association (UFA) in 1998, average mark up on unfinished wood furniture is between 75% and 100%. Wood species, quality, and craftsmanship will also play a role in the potential profits.

Figure 17. Examples of Mortise and Tenon Furniture (Courtesy of Karuk Tribal Designs).

Arts and Crafts

Within the arts and crafts market, many low value materials, or materials that typically have no value at all are coveted for unique characteristics and qualities in the wood that traditional markets have limited uses for. This makes the arts and crafts perfect for utilizing these otherwise useless materials. Logs that contain flaws that make them low value in traditional lumber markets such as stain, holes, knots, poor form, etc. can achieve a higher price from crafters. The desirability is for the natural variation that some of these characteristics can exhibit. Couple this unique quality with the skills of an artisan and arts and crafts markets are a very good example of value-added products.

Wood arts and crafts are far reaching enterprises that are limited mainly by ones imagination (Figure 18). Handmade arts and crafts combined to contribute and estimated $14 billion to the national economy in 2000 (The Craft Organization Directors Association Economic Impact Survey, 2001). The average estimated sales per household for woodcrafters specifically is $67,907 (The Craft Organization Directors Association Economic Impact Survey, 2001). Common products that are created within this market are walking sticks, furniture, lawn ornaments, doll furniture, clocks, bowls, and baskets. Craftsmanship, rarity, demand, and uniqueness determine prices. Product designs and complexity will determine the equipment needed to produce goods.

Figure 18. Snack Dispenser Constructed from Low Value Material.

Conclusion

Wildfires in the Commonwealth are becoming more dangerous every year. The number of landscapes, properties and lives that are touched by them continues to grow as our populations grow. As people seek refuge from high population centers and move into forestlands we can expect to see the number of encounters between fire and people to grow as well. In Virginia, we have seen an increase in the number of forestland to residential conversions, and along with this we have seen our number of acres burned each year increase. Forest health and management are in decline due to these population pressures, and these deteriorations will continue to add fuel to the fire.

As can be seen in the beginning of this review, education, community awareness, and mitigation activities are a necessary response to the heightened wildfire risk in the suburban/rural interface. We must educate people of the risk, and their responsibilities while living in wooded areas. We also need to create markets and revenue generating choices for individuals to pursue to alleviate fuel reduction costs. The exploitation of these markets can help to ensure that forest health and management, as well as risk reduction continues into the future.

The variety of raw materials that are available through fuel reduction activities can also create better opportunities for economic gain. Typically, an individual will not be dealing with an abundance of just one type of material. This may open many avenues. Economic outlets are needed to ensure viability and success of reduction activities. It is believed that the value-added/niche market is the simplest answer. It is the simplest because although there are expected to be large volumes of raw materials, these volumes may not necessarily be large enough to support long term, high volume, expansive commercial production. This is where the small, specialty “mom and pop” ventures can succeed.

The market and product ideas presented here are not, and should not be viewed as the only possible avenues to place the removed fuels into the market place, but rather should be seen as a starting point. Much more research is needed to determine the practicality of each of the suggested products by interested entrepreneurs. This review should be viewed as evidence that these materials do have uses and growth potential in the economies of Virginia.

Start up investments into these markets can be as nominal as $80 for a chainsaw sawmill and as expensive as $40 million for an engineered wood products plant. Most of the operations can be approached from more than one aspect. Inexpensive, 1 or 2 person operations, or expensive multiple person operations… either way, each potential product may stimulate growth in the economies of Virginia for materials long considered useless.

Due to the various species, sizes, quantities, and qualities of materials available from the removal of fuels, the type of approach to acquiring the goods should be evaluated in order to find the most economical method. Conventional forest harvesting techniques may not be the most efficient. This is mainly due to working in and around neighborhoods. Smaller lot sizes and partial volume removals are also contributors. The use of brokers, co-ops, or mediators in the market place may be the most efficient and sustainable method for the dissemination of the raw products and may provide leverage for sellers. A conglomerate type approach may satisfy these fluctuations.

In order to establish some products as a stronghold within rural economies, an effort should be made to examine the possibilities of raw materials coming from traditional forestry practices as well as mitigation activities. Pre-commercial thinnings, urban forestry practices, and land clearing for housing developments should be considered as potential sources of raw materials as well.

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VDOF P00120 ; 03/2004